

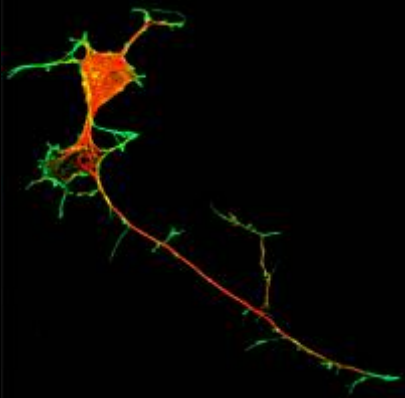
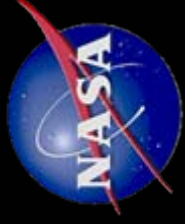
Space Exploration: Challenges in Medicine, Research, and Ethics

Jeffrey R. Davis, M.D.
Director, Space Life Sciences
NASA Johnson Space Center

27 April 2007

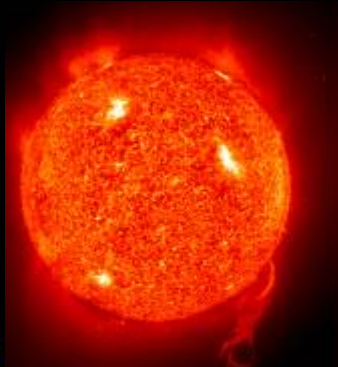


Effects of Microgravity on Human Physiology



Behavior & performance

Neurovestibular



Radiation

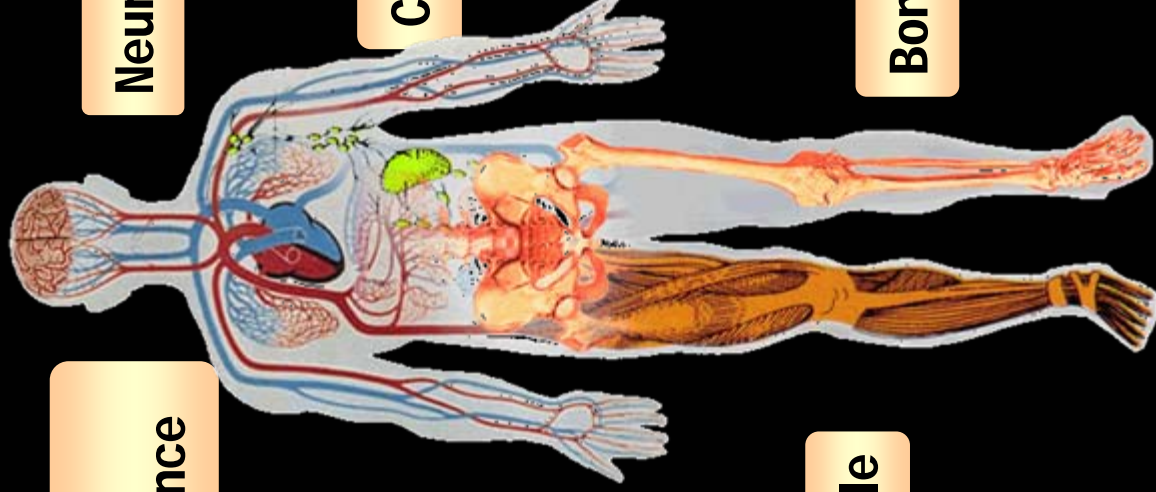
Cardiovascular



Muscle



Bone

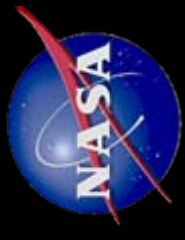
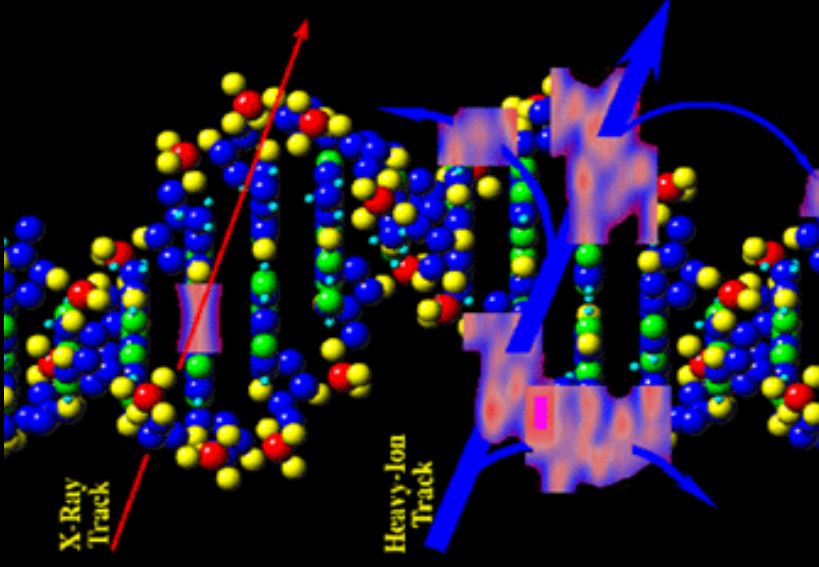


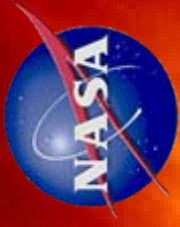
Space Studies and Results



Radiation

- Causes
 - Galactic cosmic rays
 - Protons and electrons trapped in Earth's magnetic field
 - Solar particle events
- Consequences
 - Cataracts
 - Cancer
 - Central nervous system damage
 - Acute radiation sickness





Radiation

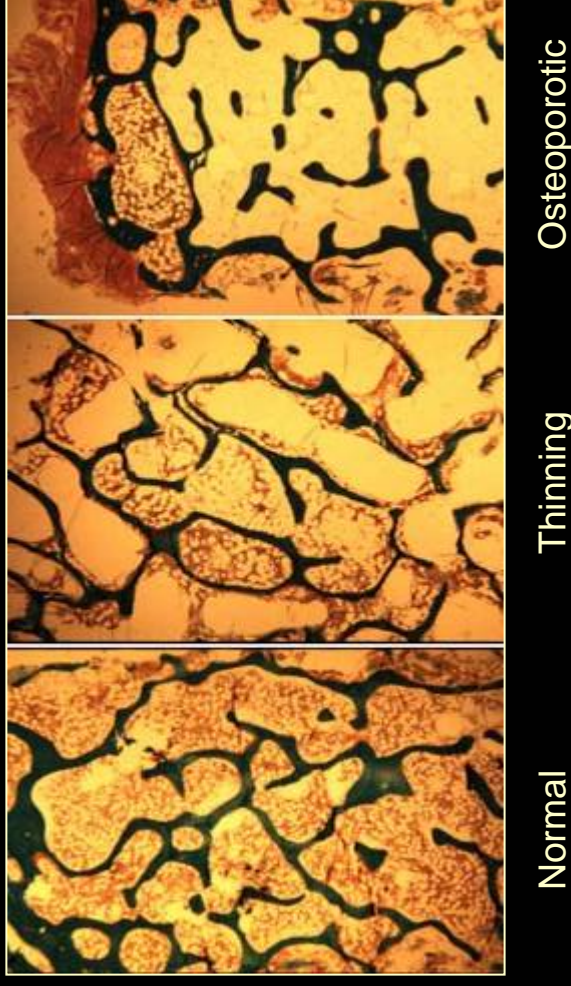
Countermeasures

- Shielding
- Pharmacotherapeutics



Bone

- Causes of bone loss
 - Interplay among biomechanical factors, hormonal and metabolic balance
 - Skeletal unloading
- Consequences
 - Increases clinical risk of
 - Stress/traumatic fractures
 - Impaired fracture healing
 - Soft tissue injury
 - Renal stone formation





Bone

- Countermeasures
 - Exercise
 - Nutrition
 - Artificial gravity
 - Pharmaceuticals
 - Midodrine for postflight orthostatic hypotension
 - Alendronate for bone loss



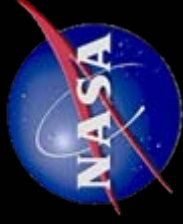


Behavior and Performance

- Causes of changes
 - Sleep loss, circadian desynchronization
 - Fatigue and work overload
 - Planned and unplanned events
 - Spacecraft environment
- Consequences
 - Stress-induced anxiety
 - Crew or crew/ground control conflict
 - Psychosomatic complaints



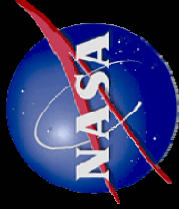
Behavior & Performance



Sunset over North America 2-1-03

Countermeasures

- Schedule changes to minimize crew fatigue and reestablish circadian rhythms
- Family contacts
- Private medical conferences
- LED blue light treatment



Muscle

- Causes of loss
 - Muscle protein synthesis
 - Lack of muscle loading
- Consequences
 - Loss of strength, power, and endurance
 - Increased excretion of muscle breakdown metabolites (nitrogen, potassium, creatine, amino acids)





Muscle

- Countermeasures
 - Medications
 - Aerobic and resistive exercise regimens



Jeffrey R. Davis, MD

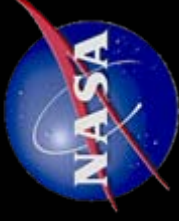


Cardiovascular

- Causes
 - Fluid pools in upper body
 - Blood volume and heart volume decrease
- Consequences
 - Aerobic capacity decreased
 - Heart rate decreased
 - Cardiac output increased



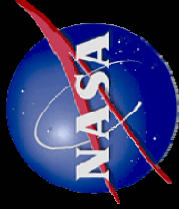
Cardiovascular



Countermeasures

- Exercise
- Pharmacology
- Treatment
 - CPR
 - Defibrillator





Neurovestibular

- Causes
 - Altered sensory stimulus
 - Rearrangement of signals from eyes, muscle, vestibular receptors
- Consequences
 - Disorientation
 - “Motion” sickness
 - Perceptual illusions
 - Disturbances of
 - Eye-hand coordination
 - Balance control
 - Gait





Neurovestibular

- Countermeasures
 - Training
 - Pharmacological
 - Spatial re-orientation





Food and Nutrition

- Causes
 - Altered senses
 - Decreased appetite
 - Stress
- Consequences
 - Decreased fluid intake
 - Decreased energy intake
 - Preference for carbohydrates versus fat
 - Body composition changes
 - Fluid and electrolyte homeostasis



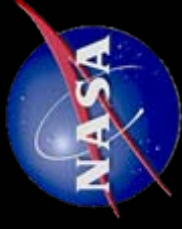


Food and Nutrition

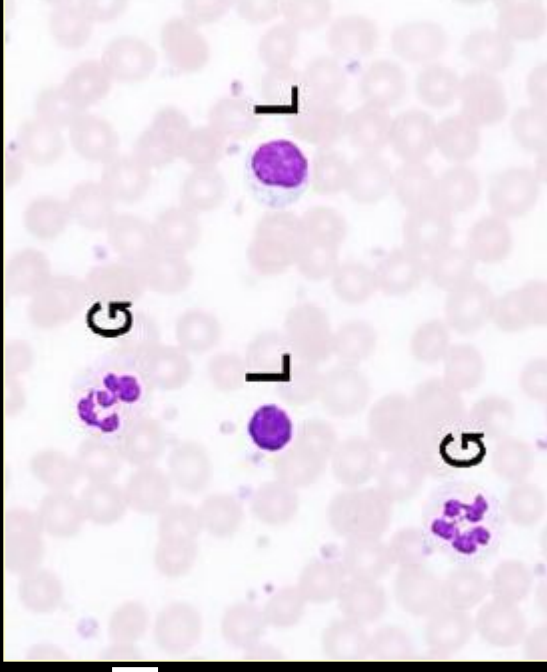
- Countermeasures
 - Satisfy metabolic requirements
 - Water balance
 - Ample pantry for crew preferences
 - Additional food
 - Increased shelf-life



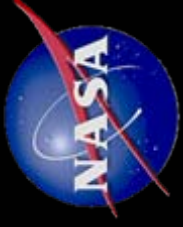
Immunology and Hematology



- Causes
 - Loss of plasma and red blood cells
 - Stress
 - Altered environmental, radiation, and chemical exposures
- Consequences
 - Decrease in red cell mass
 - Increase in white blood cell counts
 - Changes in the ability of lymphocytes to react to foreign materials
 - Number of lymphocytes decreased and neutrophils increased

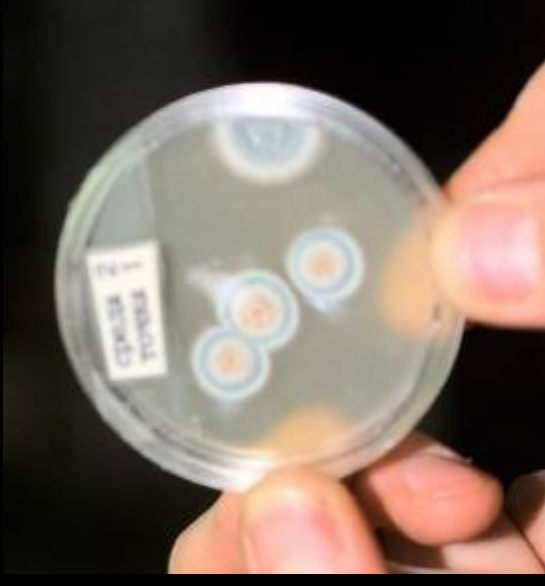


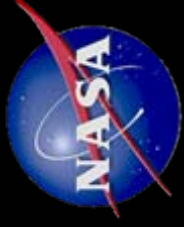
Immunology and Hematology



Countermeasures

- Shielding (structural, chemical) for radiation
- Stress reduction
- Nutritional, pharmacologic, and immunologic prevention and treatment
- Microbiocidal prevention of opportunistic infection





Environment

- Causes
 - Acoustics
 - Microbiology
 - Radiation
 - Toxicology
 - Water quality





Environment

Countermeasures

- Monitoring
- Recycling water
- Waste management
- Air scrubbers
- Thermal control systems
- Radiation shielding



The Vision for Space Exploration



Exploration



4-6 crew to lunar surface
for extended-duration stay

Long duration human
lunar exploration

2020 - TBD

2025+

2030+

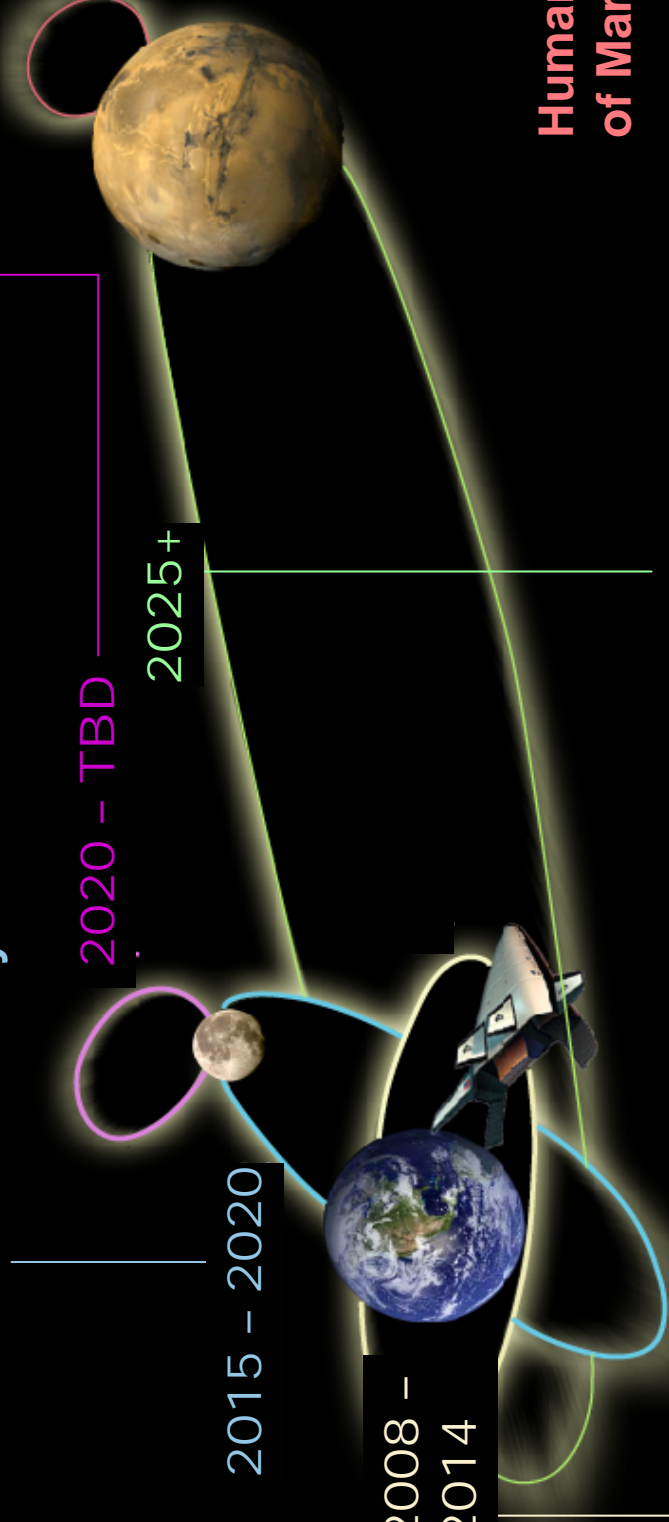
2015 - 2020

2008 -
2014

Human exploration
of Mars surface

Human exploration
to Mars vicinity

Transportation System to
Low Earth Orbit



Building Block Approach



Humans on
the Moon



Humans to
Mars



Complete
ISS



Exploration Issues

- Communication delays (up to 40 minutes to Mars) and/or long periods without communication
- Limited or no ability to return to Earth for contingencies
- Autonomous clinical care
- Psychosocial, behavior and performance issues
- Improved therapeutics
- Increased diagnostic capabilities
- Integrated micro-g and low-g diagnostic/treatment protocols
- Medical consumables

Life Sciences' Contributions

Health Care

Habitability

Environments





Health Care

- Medical requirements and standards
- Evidence-based medical care
- On-orbit clinical capabilities
- Medical selection and retention
- Crew certification
- Countermeasures
 - Physiological changes
 - Behavioral sciences





Habitability

- Human physical parameters
- Performance capabilities and limitations
- Crew station integration
- Crew interface analysis
- Habitat design
- Human-machine interfaces
- Space human factors
- Food systems





Environments



- External
 - Temperature extremes
 - Vacuum
 - Increased radiation levels (solar, cosmic)
- Internal (spacecraft)
 - Atmospheric composition and purity
 - Air, food, water, and noise
 - Spacecraft configuration
 - Microbiological concentrations & alterations



Questions?

